UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

B-52H, T/N 61-0014

OKLAHOMA CITY – AIR LOGISTICS COMPLEX
AIR FORCE SUSTAINMENT CENTER
TINKER AIR FORCE BASE, OKLAHOMA

LOCATION: TINKER AIR FORCE BASE, OKLAHOMA

DATE OF ACCIDENT: 1 NOVEMBER 2012

BOARD PRESIDENT: LT COL DAVID F. WRIGHT

CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

B-52H, T/N 61-0014
Tinker Air Force Base, Oklahoma
1 November 2012

On 1 November 2012, at approximately 1237 hours local time (L), a B-52H, tail number (T/N) 61-0014, assigned to the Oklahoma City Air Logistics Complex at Tinker Air Force Base (AFB), Oklahoma, lost the inboard flap sections from each wing shortly after takeoff. No one involved in the mishap sustained any injuries. The mishap aircraft (MA) suffered extensive damage to both wings and the fuselage. There was no damage to private property, although the flaps fell in a heavily wooded area owned by Oklahoma City. The estimated repair cost of the MA is $1.08 million.

The board president found, by clear and convincing evidence, the cause of the mishap was a failure by maintenance, specifically one maintainer (MX1), to install the retainer plugs in the forward ends of the flap drivescrew assemblies in the inboard flap actuators (#4 and #5) of both inboard flap sections on the MA.

Additionally, the board president found, by a preponderance of evidence that the following three factors substantially contributed to the mishap:

(1) the lack of an oversight requirement in the 552d Commodities Maintenance Squadron (CMMXS) Wheel and Gearbox Shop for an independent certification by another mechanic of the work done overhauling the flap drivescrew assemblies;

(2) the lack of a procedural requirement in the 565th Aircraft Maintenance Squadron Programmed Depot Maintenance dock for personnel installing the flap drivescrews to perform a cursory inspection of the flap drivescrew assemblies to verify that they are properly assembled; and

(3) the maintenance documentation practices in the 552 CMMXS Wheel and Gearbox Shop which allowed work to be signed off several days after it had been accomplished.

SUMMARY OF FACTS AND STATEMENT OF OPINION
B-52H, T/N 61-0014
1 November 2012

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

AC	Aircraft Commander
ACE	Accelerated Co-pilot Enrichment
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFMC	Air Force Material Command
AFSC	Air Force Sustainment Center
AFTO	Air Force Technical Order
AGL	Above Ground Level
AGR	Active Guard or Reservist
AIB	Aircraft Investigation Board
AMXG	Aircraft Maintenance Group
AMXS	Aircraft Maintenance Squadron
ATC	Air Traffic Control
Capt	Captain
CG	Center of Gravity
CMMXS	Commodities Maintenance Squadron
CMXG	Commodities Maintenance Group
Col	Colonel
COSO	Combat Oriented Supply Organization
CP	Chase Pilot
DASH-1	pilot flight manual
DLA	Defense Logistics Agency
DoD	Department of Defense
EPR	Engine pressure ratio
FCF	Functional Check Flight
FL	Flight Lead
FLTG	Flight Test Group
FLTS	Flight Test Squadron
FOD	Foreign Object Damage
FP	First Pilot
IAW	In Accordance With
IFE	In Flight Emergency
ILS	Instrument Landing System
IP	Instructor Pilot
Knots	nautical miles per hour
L	Local
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
Maj	Major

MAJCOM	Major Command
MARSA	Military Assumes Responsibility for Separation of Aircraft
MC	Mishap Crew
MIC	Materiel Inventory Center
MP	Mishap Pilot
MRN	Mishap Radar Navigator
MRT	Miniature Radio Transceiver
MSgt	Master Sergeant
MX	Maintainer
NOTAMS	Notices to Airmen
NSN	National Stock Number
OC-ALC	Oklahoma City Air Logistics Complex
OK	Oklahoma
Ops	Operations
OPR	Operation Number
PA	Pressure Altitude
PCS	Permanent Change of Station
PDM	Programmed Depot Maintenance
PE	Personnel Evaluation
PNF	Pilot Not Flying
QA	Quality Assurance
QVI	Quality Verification Inspection
RPM	Revolutions Per Minute
RTB	Return-To-Base
SABRE	aircraft call-sign
SAS	Stability Augmentation System
SIB	Safety Investigation Board
SPO	System Program Office
TCTO	Time Compliant Technical Order
TDY	Temporary Duty
T/N	Tail Number
T.O.	Technical Order
TRT	Take-Off Rated Thrust
v	Volume
VVI	Vertical Velocity Indicator
WCD	Work Control Document
WG	Wage Grade

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tab V).

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 19 November 2012, Lieutenant General Andrew E. Busch, Air Force Materiel Command Vice Commander, appointed Lieutenant Colonel David F. Wright to conduct an aircraft accident investigation into the 1 November 2012 mishap of a B-52H aircraft, tail number (T/N) 61-0014, near Tinker Air Force Base (AFB), Oklahoma (OK). The aircraft accident investigation was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, at Tinker AFB, OK, from 10 December 2012 through 4 January 2013. The following board members were also appointed: a Captain as the Legal Advisor, a Captain as the Maintenance Member and a Master Sergeant as the Recorder. (Tab Y-3, Y-5)

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

2. ACCIDENT SUMMARY

On 1 November 2012, at approximately 1237 hours local time (L), a B-52H, T/N 61-0014, assigned to the Oklahoma City Air Logistics Complex (OC-ALC), Tinker AFB, OK, lost the inboard flap sections from each wing shortly after takeoff. (Tab V-1.3 to V-1.9) No one involved in the mishap sustained any injuries. (Tab V-1.10) The mishap aircraft (MA) suffered extensive damage to both wings and the fuselage. (Tab J-7 to J-13) There was no damage to private property, although the flaps fell in a heavily wooded area owned by Oklahoma City. (Tab DD-3) The estimated repair cost of the MA is $1.08 million. (Tab P-4)

3. BACKGROUND

The MA was assigned to OC-ALC for Programmed Depot Maintenance (PDM), with work performed by its subordinate organizations. (Tab D-29) Upon completion, the 10th Flight Test Squadron (10 FLTS) performed a functional check flight (FCF) to ensure proper operability. (Tab V-1.3) For the purposes of operational control, 10 FLTS reported to Air Force Materiel Command via the 413th Flight Test Group. (Tab CC-17)

a. Air Force Materiel Command (AFMC)

AFMC headquarters are located at Wright-Patterson AFB, Ohio. AFMC's mission is to deliver war-winning expeditionary capabilities to the warfighter through development and transition of technology, professional acquisition management, test and evaluation, and sustainment of all Air

Force weapon systems. This mission is fulfilled through five specialized centers; Air Force Research Laboratory and Air Force Life Cycle Management Center, both headquartered at Wright-Patterson AFB; Air Force Test Center, headquartered at Edwards AFB, California; Air Force Sustainment Center, headquartered at Tinker AFB, OK; and Air Force Nuclear Weapons Center, headquartered at Kirtland AFB, New Mexico. (Tab CC-3)

b. Air Force Sustainment Center (AFSC)

AFSC headquarters are located at Tinker AFB, OK. The mission of AFSC is to sustain weapon system readiness. AFSC is commanded by a three-star general and consists of more than 32,000 military and civilian personnel. AFSC provides installation support to more than 141 Associate Units with more than 75,000 personnel. AFSC provides execution and consolidation oversight of maintenance, supply chain activities and installation support. In addition, staff and home offices include engineering, financial management, contracting, small business, personnel, judge advocate, safety, historian and logistics. These offices help ensure planning, policy, guidance and procedures are effectively implemented and executed for the Center. (Tab CC-7)

c. Oklahoma City Air Logistics Complex (OC-ALC)

OC-ALC located at Tinker AFB, OK performs PDM on the KC-135, B-1B, B-52 and E-3 aircraft; expanded phase maintenance on the Navy E-6 aircraft; and maintenance, repair and overhaul of aircraft engines for the Air Force, Air Force Reserve, Air National Guard, Navy and foreign military sales customers. Additionally, the Complex is responsible for the maintenance, repair and overhaul of a wide variety of Air Force and Navy airborne accessory components, and the development and sustainment of a diverse portfolio of operational flight programs, test program sets, automatic test equipment, and industrial automation software. OC-ALC employs over 9,400 military and civilian personnel with 98 different job skills. The Complex utilizes 63 buildings and 8.2 million square feet of industrial floor space in support of its mission. (Tab CC-9)

d. 76th Aircraft Maintenance Group (76 AMXG)

76 AMXG directs, manages and accomplishes organic depot-level maintenance, repair, modification, overhaul, functional check flights and reclamation of B-1, B-52, C/KC/EC-135, C-130, E-3 and E-6 aircraft. The group conducts depot support operations on a fleet of Air Force, Air Force Reserve, Air National Guard, Navy and foreign military sales aircraft, as well as expeditionary combat-logistics depot maintenance and distribution support. 76 AMXG is responsible for the welfare and training of more than 2,600 military and civilian personnel in 10 facilities. (Tab CC-24) The

Group consists of three production squadrons, three support divisions, and the expeditionary maintenance flight, which provides forward deployed expeditionary maintenance, crash-damage repair, and rapid area distribution support personnel for worldwide depot-level maintenance, supply, transportation, and battle damage repair. (Tab CC-11)

e. 565th Aircraft Maintenance Squadron (565 AMXS)

565 AMXS is responsible for all facets of depot level maintenance on the B-52 and B-1 fleets. The B-52 side coordinates closely with the Systems Program Office (SPO), Defense Logistics Agency (DLA) and the 448th Supply Chain Management Group for daily execution, as well as with over 25 other local agencies. It is responsible for directing a 612,000 annual work-hour program, along with planning, directing, integrating and executing all aspects of the production of aircraft within a $233 million maintenance operating budget. (Tab CC-13)

f. 76th Commodities Maintenance Group (76 CMXG)

76 CMXG is responsible for inspecting, repairing and testing 3,500 types of end items and 400 different secondary structures for jet engines, aircraft and cruise missiles. 76 CMXG delivers engine components for fuel systems, oil systems, electronics systems and hydraulic systems, including main bearings, oil pumps, fuel pumps, main fuel controls, afterburner fuel controls, fuel nozzles and afterburner fuel nozzles, electrical cables, exciter boxes, generators and spark plugs. In addition, 76 CMXG repairs avionics, flight controls, cowlings, constant speed drives, hatches, refueling booms, nose cones, radomes, horizontal stabilizers and breathable oxygen systems in support of B-1, B-52, E-3, E-6 and KC-135 weapon systems. (Tab CC-24)

g. 552d Commodities Maintenance Squadron (552 CMMXS)

552 CMMXS consists of two production flights; the Aircraft and Engines Accessories Flight, and the Fuel Controls/ Test and Fuel Accessories Flight. The Aircraft and Engines Accessories Flight performs maintenance and refurbishment on items such as constant speed drives, wheels and tires, valve/ governor and electrical accessories on three different weapon systems, including the B-52. The Fuel Controls/ Test and Fuel Accessories Flight performs overhauls and testing on fuel controls, electrical accessories, pumps, manifolds and fuel on multiple weapon systems. The CMMXS has 451 employees, spread out over 8 different buildings, which annually produce over 18,000 end items with a total output of approximately 589,000 man-hours. (Tab CC-15)

h. 413th Flight Test Group (413 FLTG)

413 FLTG is an Air Force Reserve Command unit, stationed at Robins AFB, Georgia as a tenant unit. 413 FLTG conducts flight tests on aircraft after the PDM overhaul is completed. Components of the unit are stationed throughout the United States to help conduct functional flight tests. The Group is a partnership between AFMC and the Air Force Reserve Command,

and is the operational supervisor of all the depot flight test units. The Group manages 4 squadrons and 2 flights, made up of 140 full-time Airmen, 78 traditional reservists and 9 civil servants. (Tab CC-19)

i. 10th Flight Test Squadron (10 FLTS)

10 FLTS plans, schedules and directs the OC-ALC functional check flight program. 10 FLTS assesses airworthiness of B-1B, B-52, E-3, and KC-135 aircraft following depot maintenance and major modifications, recovers non-airworthy or damaged aircraft from worldwide locations, and supports program offices by determining flight test requirements and procedures. 10 FLTS is a tenant unit based at Tinker AFB, OK. It falls under the 413 FLTG at Robins AFB, Georgia. (Tab CC-17)

j. B-52H Stratofortress

The B-52H is a long-range, heavy bomber that can perform a variety of missions. The bomber is capable of flying at high subsonic speeds at altitudes up to 50,000 feet. It can carry nuclear or precision guided conventional ordnance with worldwide precision navigation capability. (Tab CC-21)

In a conventional conflict, the B-52 can perform strategic attack, air interdiction, offensive counter-air and maritime operations. For more than 40 years the B-52 has been the backbone of the manned strategic bomber force for the United States. Current engineering analyses show the B-52's life span extends beyond the year 2040. The B-52A first flew in 1954, and the B model entered service in 1955. A total of 744 B-52s were built with the last, a B-52H, delivered in October 1962. Only the H model is still in the Air Force inventory and is assigned to Air Force Global Strike Command and the Air Force Reserves. (Tab CC-21 to CC-22)

4. SEQUENCE OF EVENTS

a. Mission

The mishap mission was planned as a functional check flight (FCF) to confirm the aircraft's serviceability following a complete overhaul performed as part of Programmed Depot Maintenance (PDM) by the 565 AMXS at OC-ALC at Tinker AFB, OK. (Tab V-1.3) 10 FLTS planned the sortie to follow a normal FCF profile with an expected duration of approximately 3 hours. (Tab K-3) The FCF crew consisted of the two mishap pilots, MP1 and MP2, as well as the mishap radar navigator (MRN). (Tab V-1.3 to V-1.5, V-3.1) Besides the FCF objectives, this flight was to serve as a qualification sortie as part of MP2's training to become an FCF pilot, with instruction given by MP1, an FCF-qualified instructor pilot. (Tab V-1.5) This was MP2's fourth flight in the qualification training program, which he began on 28 September 2012. (Tab V-2.1) The flight was scheduled for 31 October 2012. (Tab V-1.4) However, the mishap crew (MC) cancelled the mission due to problems with one of the eight engines encountered during pre-flight ground checks. (Tab V-1.4) The MC flew the mission the next day after maintenance corrected the engine problems. (Tab V-1.4) The 10 FLTS commander at Tinker AFB, OK authorized the mission. (Tab DD-17)

b. Planning

MP1 led the mission planning in accordance with (IAW) AFIs and local guidance. (Tab V-1.3) The MC assembled at the 10 FLTS operations building on the morning of 31 October 2012, and MP1 reviewed the aircraft forms and briefed the sortie. (Tab V-1.4) Squadron supervision did not attend the briefing, per normal squadron procedures. (Tab DD-17) MP1, as the Aircraft Commander, briefed the operations supervisor on administrative flight information, weather, Notices to Airmen (NOTAMs), aircraft status and all items necessary to safely execute the planned FCF. The operations supervisor then cleared the MC to proceed to the aircraft. All crewmembers understood the briefing and had no questions as they departed for the mishap aircraft (MA). (Tab V-1.5)

c. Preflight

The MC departed the squadron operations area, picked up their life support equipment, then continued to the MA. The MC arrived at the MA and conducted a pre-flight walk-around inspection with no problems noted. (Tab V-1.5) The MC and maintenance personnel conducted ground checks IAW normal FCF procedures, with the MA remaining in its parking spot. (Tab V-1.4) FCF checks of the aircraft flaps included checking and timing flap function with both flap motors operating together and with each motor individually. (Tab V-1.11) All MA systems worked normally except for the #1 engine, which the MC was unable to start, and the #3 generator, whose voltage was out of tolerance. (Tabs V-1.4, D-44 and D-46) After extended trouble-shooting of the engine problems, the MC decided to cancel the FCF for that day and let maintenance fix the problems. (Tab V-1.4)

The next day (1 November 2012), the MC waited for notification from maintenance that the problem was fixed. (Tab V-1.4) Upon notification, MP1 reviewed the briefing information covered the day before with the MC and re-briefed current weather, NOTAMs and FCF sortie profile. The MC proceeded to the MA with their equipment at approximately 1100L. Since the majority of the FCF ground checks were accomplished the day before, the only FCF-specific ground checks conducted on the day of the mishap focused on the #1 engine. All other systems were checked IAW normal flight procedures. (Tab V-1.5) Specifically, the MC performed normal flap checks, including a full retraction and extension cycle, with nothing remarkable noted. (Tab V-1.11 to V-1.12)

d. Summary of Accident

After pre-taxi checks were completed, the MC taxied to Runway 18 at Tinker AFB. (Tab V-1.5) Winds at takeoff were calm and the sky was clear, with unrestricted visibility. (Tab F-5) MP2 performed a normal takeoff at 1235L, using 100% flaps (fully extended). (Tab V-1.11 to V-1.12) Gear retraction was normal. (Tab V-1.5) At approximately 1,000 feet above ground level and 180 knots, MP1 initiated flap retraction using the flap lever on the center console in the cockpit. (Tab V-1.12)

During flap retraction, as the flap position indicator approached 50%, the MC heard a loud noise described as a "bang-boom-thud." The MA started a roll to the left, which MP2 was unable to control. MP1 reached for the controls to assist MP2 and then assumed control of the aircraft. MP1 continued countering the roll, reaching full right yoke and full right rudder; however, the aircraft continued to roll left, reaching between 30 and 45 degrees of left bank. (Tab V-1.6)

While the pilots were attempting to regain control of the aircraft, about 20-30 seconds after the first "bang," they heard a second similar noise and the aircraft became controllable. The MC began turning the MA back towards the runway at Tinker AFB and declared an emergency with Oklahoma City air traffic controllers. (Tab V-1.6) At this point, the MC could not determine what caused the noises and the control problems. (Tab V-1.7)

Subsequent investigation revealed the first sound heard by the MC was the right inboard flap separating from the wing due to a failure of its inboard actuator. The second sound was the left inboard flap departing the aircraft for the same reason. (Tabs Z-73 and DD-3) The windows in the B-52 did not allow the MC to observe the inboard flap area of the wings, so they were unable to see anything to explain the noises and control problems. (Tab V-1.7)

Upon request from the MC, air traffic controllers directed a T-38 in the local area to join in formation with the MA to inspect the outside of the aircraft. (Tab AA-14) The T-38 was on a training mission from Vance AFB, OK with an instructor pilot in the front seat and a student pilot in the rear seat. The instructor pilot had been previously qualified in the B-52, with over 1,000 hours of B-52 experience. (Tab DD-5)

The T-38 paced the B-52 and the pilots reported observing that both of the inboard flap sections on the B-52's wings were missing, except for a relatively small portion of the left flap. They reported no other damage. (Tab AA-16 to AA-17) After a few minutes, the T-38 withdrew in order resume their mission, and returned to Vance AFB. (Tab DD-6)

Based upon the observations of the T-38 pilots, the MC consulted with their squadron operations personnel on the appropriate procedure to safely land the damaged aircraft. (Tab V-1.9)

A highly experienced B-52 crew was in the 10 FLTS building, on temporary duty (TDY) from the 93d Bomb Squadron at Barksdale AFB, Louisiana. (Tab V-1.9) Their insight was invaluable in developing a sound recovery plan since the MC was the only B-52 qualified aircrew assigned to Tinker AFB. (Tab V-1.8 to V-1.9) The B-52 flight manual does not address loss of both inboard flap sections. (Tab V-1.9) The most applicable procedures addressed in the manual involved the situation where both flaps were stuck in raised or lowered positions, or split flaps where the left and right side were stuck in different positions. (Tab DD-17) Squadron operations personnel also made contact with engineers at a Boeing office, the original aircraft manufacturer. (Tab V-1.9)

After considering all the information available, the MC decided to orbit over sparsely populated areas southeast of Tinker AFB to burn fuel and reduce weight in order to allow a lower no-flap approach speed. (Tab V-1.8) After almost two hours, the MC performed a controllability check and proceeded to make by an emergency landing on Runway 18 at Tinker AFB at 1438L. The MC stopped the MA safely on the runway, where they shut down and exited the aircraft. There were no injuries to the MC. (Tab V-1.10)

Shortly after takeoff, airfield management personnel had found a broken metal piece, later determined to be part of the left inboard flap actuator, on the runway at a point shortly after where the MA became airborne. (Tabs Z-74, AA-9 and DD-21) In addition, during the flight, witnesses on the ground south of Tinker AFB called local law enforcement agencies, reporting they had seen large parts falling from an aircraft. (Tab V-4.1) A law enforcement helicopter searched for the parts and located them in a densely forested area approximately 5 miles south of the base. (Tab N-40 to N-42) Tinker AFB personnel identified the parts as the right and left inboard flaps, which were mostly intact. In order to recover the flaps, Tinker AFB personnel had to cut them into smaller pieces. (Tab DD-3) No personnel on the ground were injured.

e. Impact

Not applicable.

f. Egress and Aircrew Flight Equipment

Not applicable.

g. Search and Rescue

Not applicable.

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms are used to document aircraft maintenance, inspections, servicing, and airworthiness of the aircraft IAW T.O. 00-20-1. (Tab BB-18) However, when an aircraft is inducted into a depot maintenance facility, these forms are transcribed into work control documents (WCD) for input into the Programmed Depot Maintenance Scheduling System. (Tab DD-13) WCDs represent an official record of tasks performed by mechanics during the PDM process. (Tab BB-20)

A detailed review of the active AFTO forms and the WCDs for the MA covering the PDM period prior to the mishap revealed that maintenance documentation was satisfactorily accomplished IAW applicable maintenance directives. (Tab DD-13)

b. Inspections

Every 4 years, each B-52 aircraft rotates through the depot facility for PDM. This process is an inspection and correction of defects requiring equipment and/ or facilities not normally available at operating locations. (Tab BB-19) PDM personnel disassemble, refurbish, reassemble, paint, and flight-test each B-52 prior to releasing it back to its home station. (Tabs D-29, BB-19, BB-23 and CC-13) At the time of mishap, the MA had 16,634.7 airframe hours and 565 AMXS had completed a scheduled PDM overhaul package on the MA. (Tab D-25)

c. Maintenance Procedures

565 AMXS inducted the MA into OC-ALC for PDM on 31 May 2012. (Tab D-29) 565 AMXS disassembled the entire aircraft and routed the parts to appropriate back shops within OC-ALC for further maintenance. (Tab CC-13) The back shops overhauled the components to serviceable condition and routed the components back to 565 AMXS for installation on the MA. (Tab CC-15)

A review of the MA's AFTO 781 forms and WCDs revealed all maintenance actions were accomplished IAW standard approved maintenance procedures described in applicable AFIs, technical orders and local procedures. (Tab DD-13)

d. Maintenance Personnel and Supervision

A review of training records showed the personnel who performed the maintenance on the MA, were appropriately trained, experienced, and certified to complete the assigned tasks. (Tabs G-25 to G-41, G-45 to G-48, and DD-13)

e. Fuel, Hydraulic and Oil Inspection Analyses

AFTO 781H shows the MA was fueled and had adequate oil in all eight engines on 31 October 2012. On 1 November 2012, the MA received 60 liters of liquid oxygen. All of these were within allowable limits. (Tab D-26)

There are no records showing any fuel, oil, or liquid oxygen samples were collected after the MA landed; however, there is no evidence issues with fuel, oil, or liquid oxygen contributed to this mishap.

f. Unscheduled Maintenance

IAW AFI 21-102, an FCF is performed at the end of PDM to ensure the aircraft is airworthy. Before the aircraft becomes airborne, the aircrew will run through a series of ground checks. (Tab BB-23) The MC reported the following three discrepancies on 31 October 2012:

(1) MP2 reported the #1 engine would not start. After cancelling the FCF, maintenance personnel corrected the problem by resetting the circuit breaker controlling the #1 engine firewall fuel shut-off valve. They tested the #1 engine through several starting cycles with no failures. (Tab D-44)

(2) MP1 reported, "the copilot's interphone switch in the toggle up position is intermittent." Maintenance personnel removed and replaced the copilots interphone control box, to include the faulty switch. (Tab D-45)

(3) MP2 reported the #3 generator voltage as out of tolerance. Maintenance personnel removed and replaced the voltage regulator. (Tab D-46)

There is no evidence these unscheduled maintenance actions contributed to the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

Aircraft damage was limited to the inboard wing flaps, wing structure around the flap attachment points, and fuselage skin near the inboard flaps. (Tab J-7 to J-12) To understand the sequence of events that led to the separation of the flaps, it is important to understand the system's design and terminology, as well as the maintenance processes followed to overhaul this system during PDM.

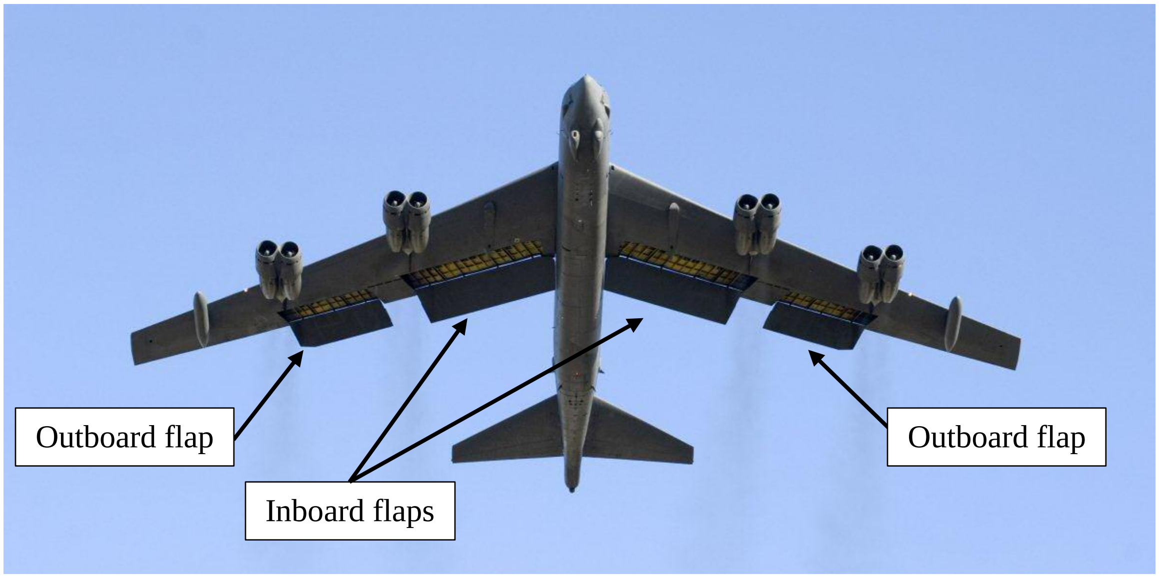

Figure 1. B-52 Flap Locations

(1) Flap System Description

The B-52 is equipped with inboard and outboard flaps along the trailing edge of the wings. (see Figure 1) Although the technically correct term is inboard and outboard flap sections, this report simply refers to the inboard and outboard flaps for clarity. (Tab J-6) The B-52 uses spoilers mounted on the top of the wings, as opposed to ailerons, to control roll. (Tab V-1.6) Each inboard flaps is approximately 32 feet long and 9 feet wide, and 2,300 pounds. The outboard flaps are approximately 22 feet long and 6 feet wide, and 1,400 pounds each. (Tab DD-13)

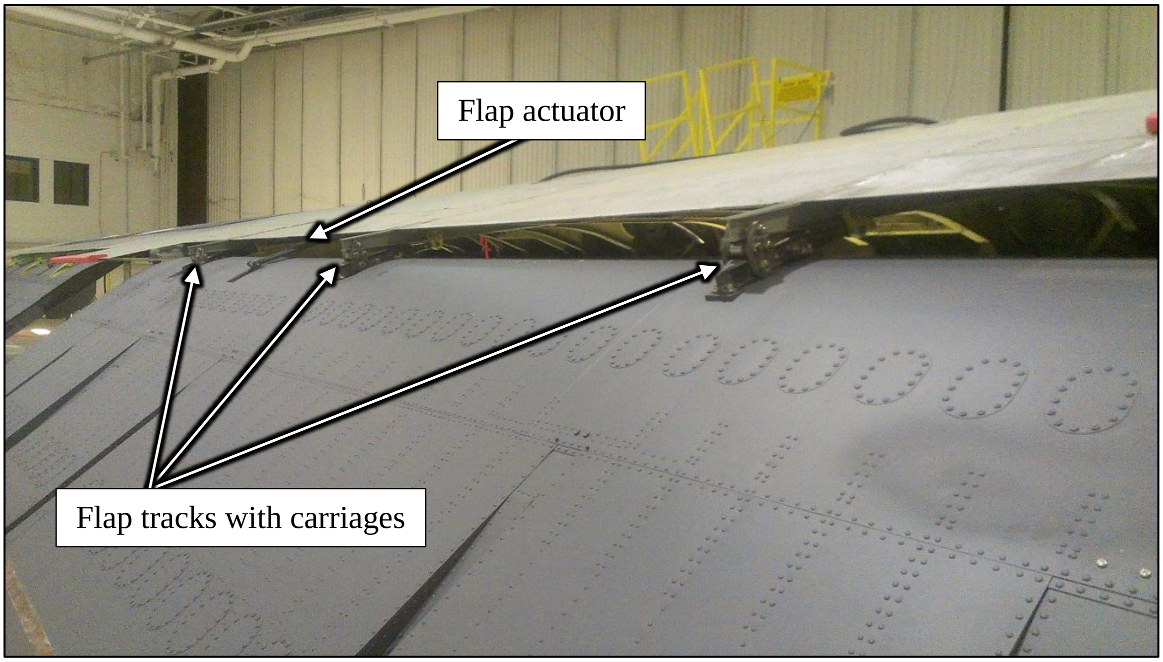

Figure 2. Flap Tracks, Carriages and Actuator Connections

The flaps slide forward and aft under the wings by means of wheeled carriages rolling along flap tracks. (see Figure 2) Each inboard flap is supported by four tracks and each outboard flap is supported by three tracks. (Tab J-6) The fore and aft flap position is driven by two actuators per flap. The flap tracks do not prevent the flap from sliding off the aft end of the track – they are only meant to support the weight of the flap pulling downwards. (Tab J-6, J-17) Likewise, the flap actuators are not designed to support the weight of the flap – they provide the fore and aft strength to keep the flap on the track and power the flap movement commanded by the pilots. On the B-52, the flap actuators are known as flap drivescrew assemblies. (Tab J-6)

Electric motors power the flap drivescrew assemblies via a series of torque tubes and gearboxes, which cause the flap drivescrews to rotate. Each flap is attached to two flap drivescrew nuts, which run fore and aft along the drivescrews as they rotate. (Tab J-6) This system is depicted in Figures 3 and 4 below. (Tab Z-56)

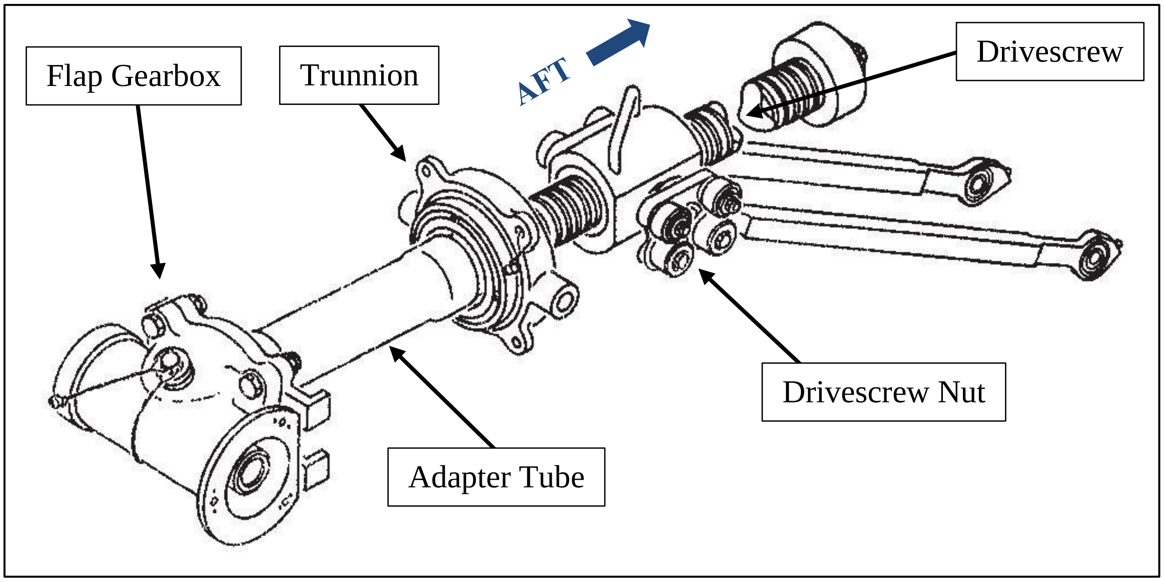

Figure 3. B-52 Flap Drivescrew Diagram

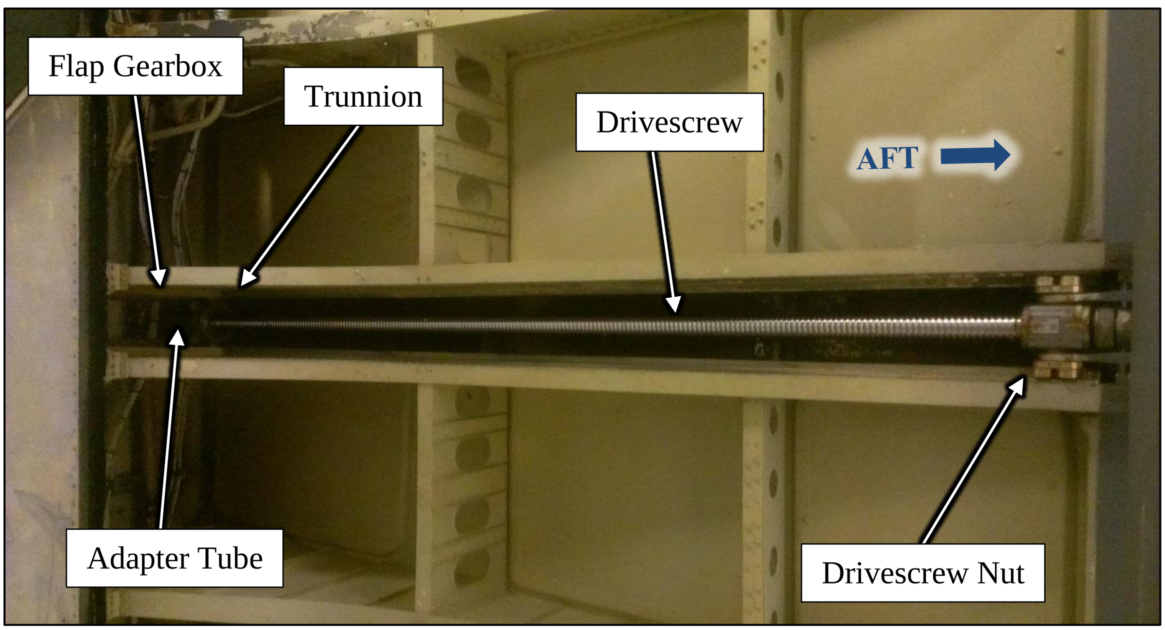

Figure 4. B-52 Flap Drivescrew Mechanism

Pilots control the flaps by means of a flap control lever, which has three positions: up, down or off. (Tab V-1.18) The off position holds the flaps at any intermediate position. The flap position is indicated in the cockpit by a gauge measuring the percent of flap extension from 0% to 100%. (Tab V-1.7)

(a) Flap Drivescrew Locations

The specific design of the drivescrew assemblies that move the flaps vary based on their positions. For reference, they are numbered from the aircraft's left to right as follows:

#1 – left outboard flap, outboard drivescrew
#2 – left outboard flap, inboard drivescrew
#3 – left inboard flap, outboard drivescrew
#4 – left inboard flap, inboard drivescrew
#5 – right inboard flap, inboard drivescrew
#6 – right inboard flap, outboard drivescrew
#7 – right outboard flap, inboard drivescrew
#8 – right outboard flap, outboard drivescrew

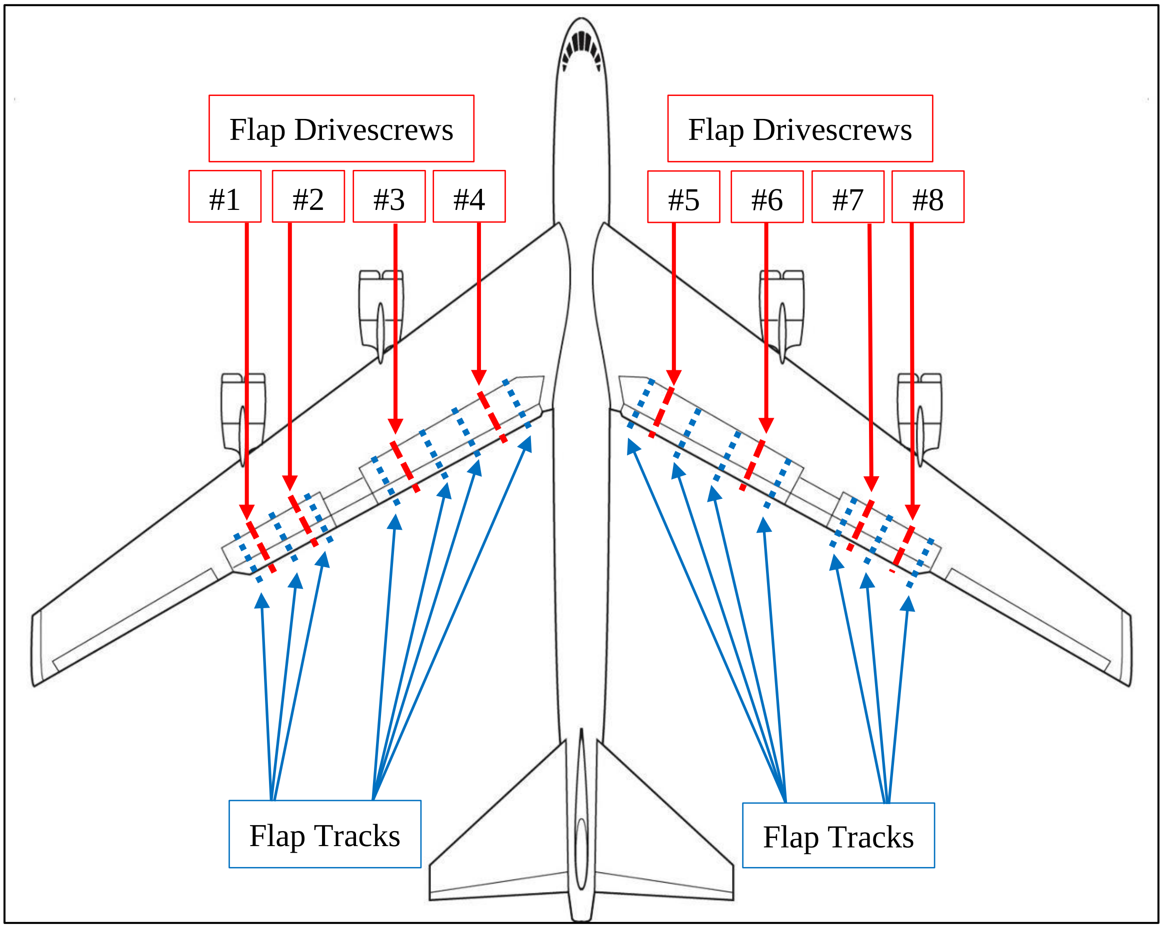

Figure 5. B-52 Flap Drivescrew and Track Locations (approximate)

(b) Flap Drivescrew Assembly Details

Due to the tapered shape of the wing, the length of the drivescrews varies. On each flap, the inboard drivescrew requires an adapter tube to provide the additional length required to reach the gearbox. (Tab J-6) The adapter tube transmits the rotational movement from the gearbox to the drivescrew via a splined adapter and retainer plug mounted on the end of the drivescrew, whose gear teeth fit into matching grooves inside the adapter tube, as shown in Figures 6 to 9. (Tab Z-54) The splined adapter is held in place by the retainer plug, which screws into the end of the drivescrew. The splined adapter and retainer plug prevent the drivescrew from separating from the trunnion. The trunnion anchors the drivescrew to the wing by two bolts, which run through the walls of the drivescrew housing on the underside of the wing. (Tab J-6)

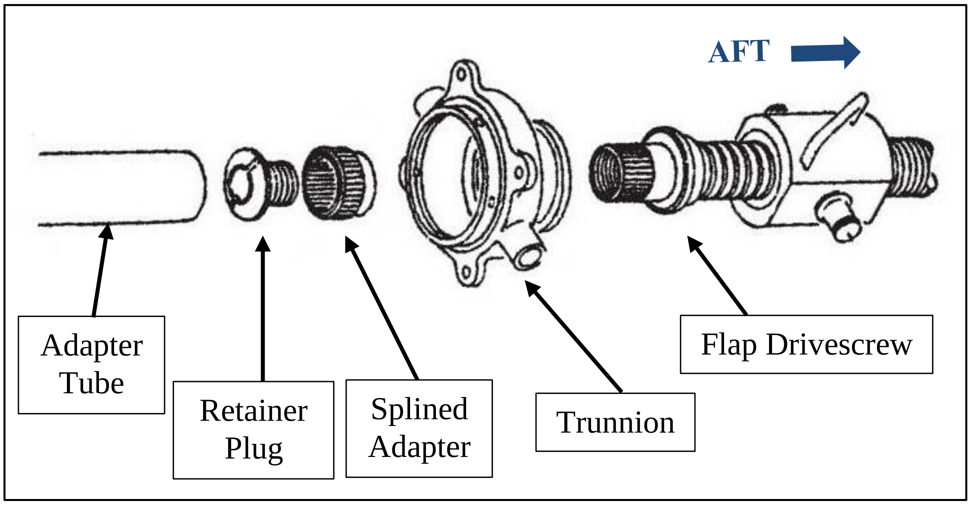

Figure 6. B-52 Flap Drivescrew Assembly

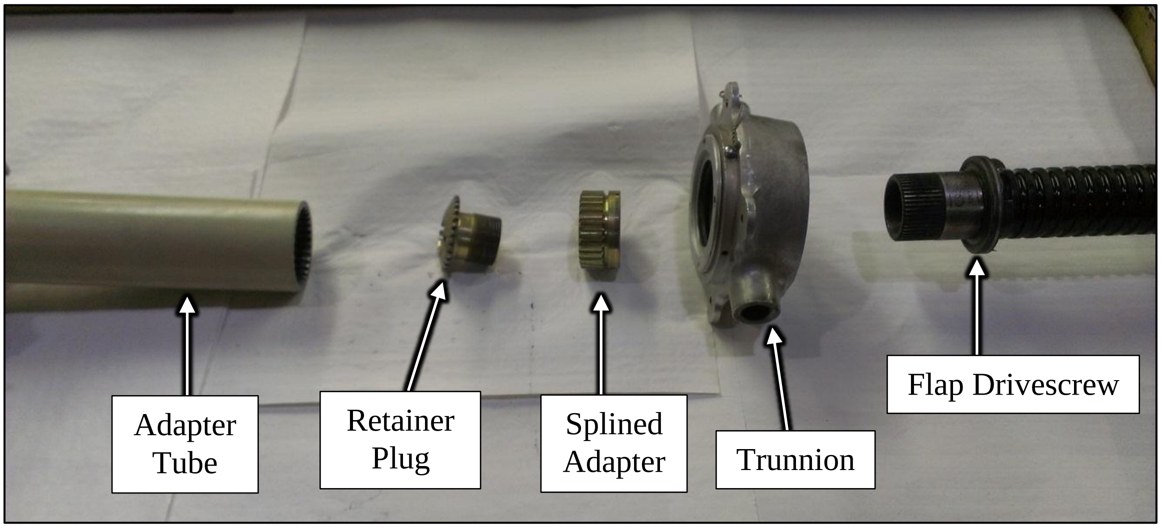

Figure 7. B-52 Flap Drivescrew Assembly

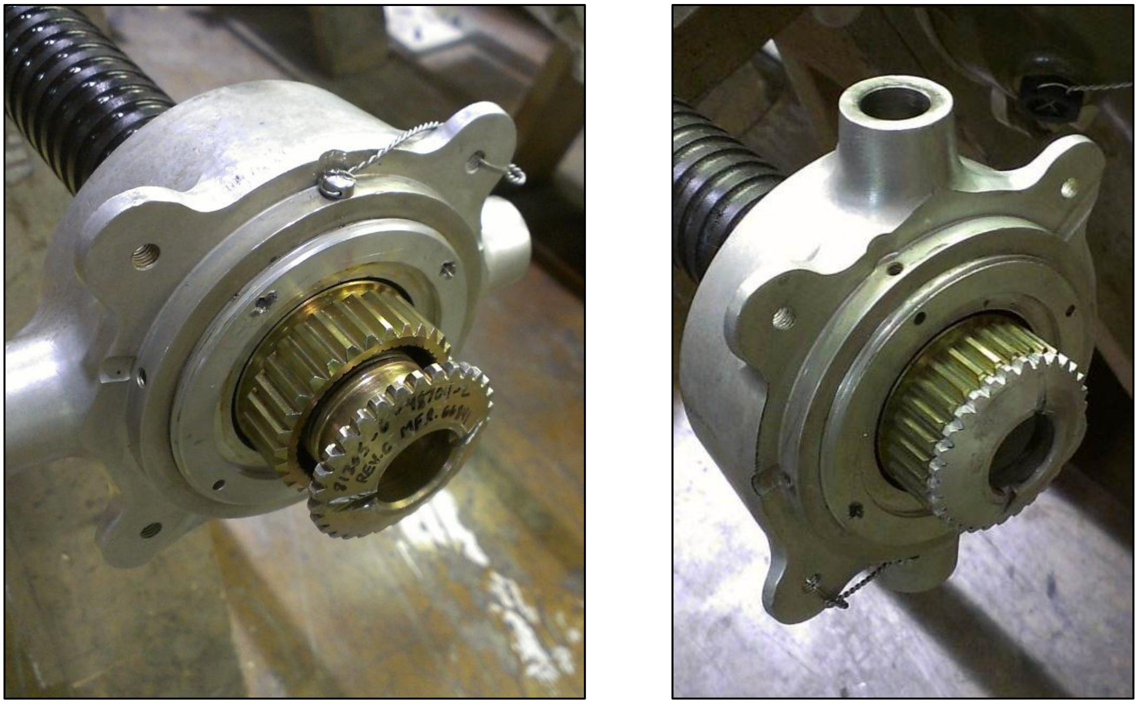

Figure 8. B-52 Flap Drivescrew Retainer Plug Installation

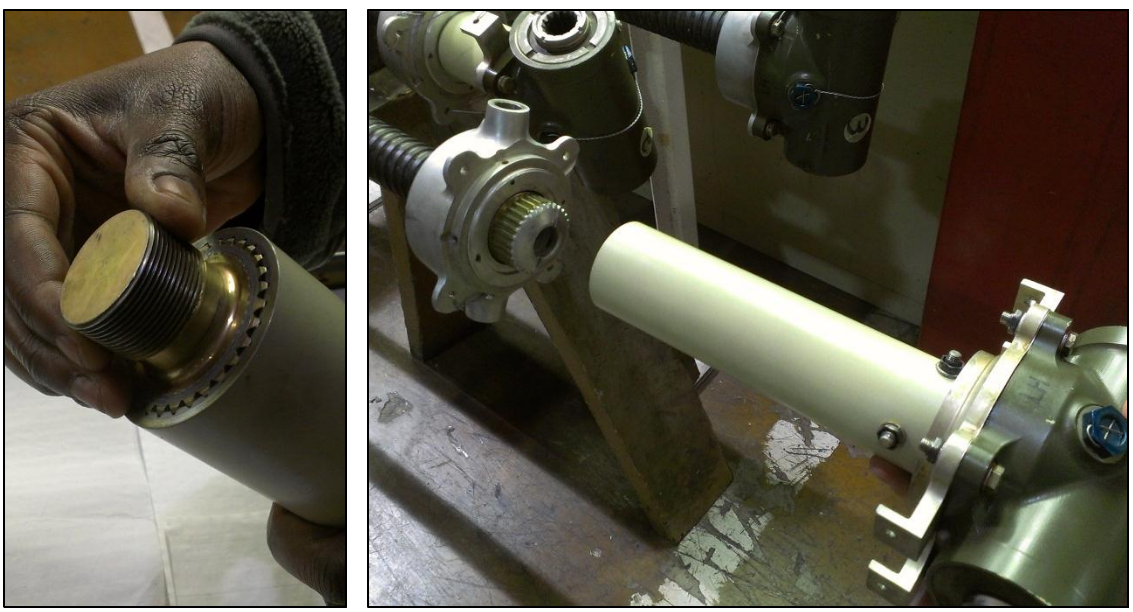

Figure 9. B-52 Flap Drivescrew Adapter Tube Assembly

(c) Flap Drivescrew Supports

The aft end of the flap drivescrew is supported by an end plate, which is fastened to the wing at the walls of the drivescrew housing, as shown in Figure 10. The drivescrew nut that runs fore and aft on the drivescrew has a set of wheels that run along tracks on the inside of the drivescrew housing. (Tab J-6)

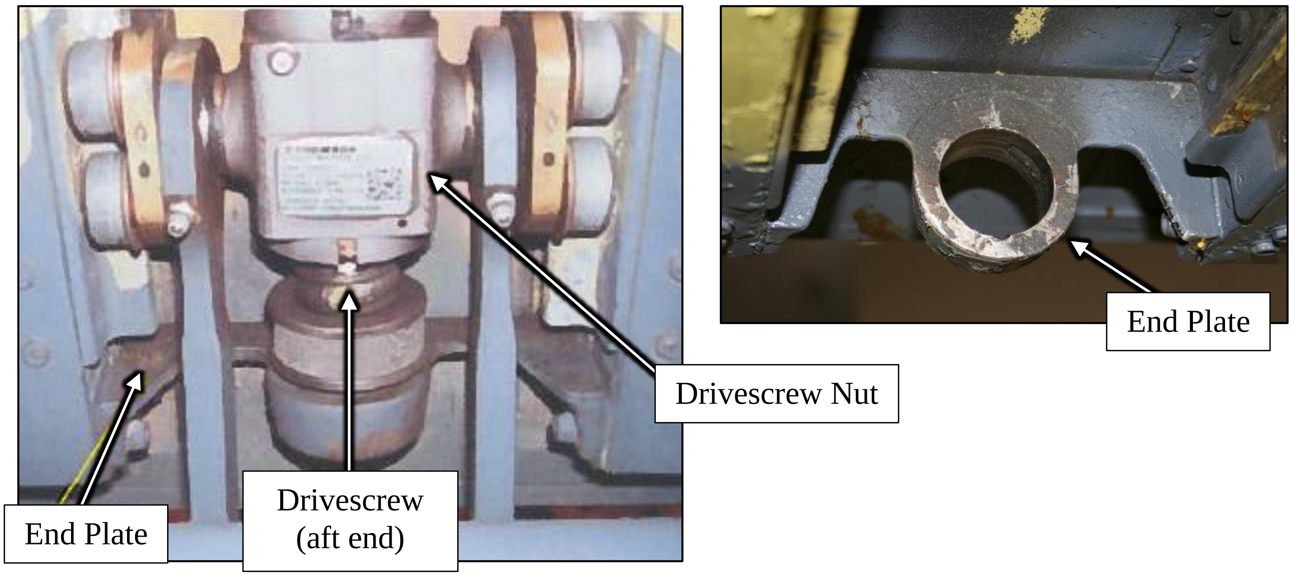

Figure 10. B-52 Flap End Plate and Drivescrew Nut Assemblies

(d) Forces on the Flap Drivescrews

When the aircraft is parked on the ground, the only significant force affecting the flap system is the weight of the flaps, pulling them downwards. Each flap's weight is primarily supported by the carriages riding on the flap tracks under the wings. (Tab J-6)

When the aircraft is in flight, aerodynamic drag creates an additional force pushing aft against the flaps. The primary mechanism countering this drag is the assembly at the forward ends of the flap drivescrews. On the inboard drivescrew of each flap (#4 and #5), this is located at the trunnion where the flap drivescrew connects to the adapter tube. The retainer plug that screws into the forward end of the flap drivescrew prevents the drivescrew from sliding aft due to drag. (Tab J-6, J-17) The end plate on the aft end of the drivescrew provides a small measure of strength to resist the drivescrew sliding aft, but it was not designed to bear the full load. (Tab J-18)

(e) Retainer Plug Details

The retainer plug, shown in Figure 11, measures approximately 1.8 inches long and 1.8 inches in diameter and is made of steel. (Tab U-15) Its cap is machined with gear teeth to match the teeth on the splined adapter and slide into the grooves inside the adapter tube. (Tab Z-3 to Z-9) These teeth prevent the retainer plug from rotating once the set is assembled and therefore serve as an anti-rotation provision. (Tab J-19)

Figure 11. Flap Drivescrew Retainer Plug

(2) Flap System PDM Process Description

(a) 565th Aircraft Maintenance Squadron (AMXS)

As part of the PDM tear-down, 565 AMXS removed the flaps and flap drivescrew assemblies in the PDM dock, located in building 2121. (Tab CC-13) 565 AMXS routed the drivescrew assemblies to the 552 CMMXS Wheel and Gearbox Shop to be serviced. (Tabs D-71 to D-90, and CC-15)

After overhaul, 565 AMXS installed all 8 flap drivescrew assemblies and mounted the flaps in the PDM dock. (Tab U-17 to U-18) The flap system went through numerous operational checks using external air motors for initial adjustments and using the aircraft's electrical flap motors for final checks, prior to the FCF. (Tab D-92 to D-114)

(b) 552d Component Maintenance Squadron (CMMXS)

552 CMMXS Wheel and Gearbox Shop, which serviced the MA flap drivescrew assemblies, was located in building 2210. (Tabs V-5.2 and DD-9) There, an Aircraft Parts Repair mechanic disassembled all eight drivescrew assemblies to their individual components. The mechanic cleaned, inspected, replaced and reassembled each component, signed off on each drivescrew

WCD, and placed a serviceable tag on each assembly. (Tab D-75 to D-90) Finally, the completed set of flap drivescrew assemblies was sent back to 565 AMXS for installation on the aircraft. (Tab D-90)

b. Evaluation and Analysis

(1) Evaluations Performed

(a) Technical Report by B-52 System Program Office (SPO)

The B-52 SPO prepared a Technical Report dated 19 November 2012. (Tab J-3) The report detailed the inspections performed on the aircraft after landing, as well as on the left and right flap sections recovered from the wooded area south of Tinker AFB. (Tab J-7 to J-13)

(b) Post-Mishap Time Compliant Technical Order (TCTO)

A one-time inspection/ TCTO was issued for 8 B-52 aircraft after the mishap on 1 November 2012. The TCTO called for an inspection of the flap drivescrew assemblies for installation of retainer plugs. The TCTO did not result in any significant findings. (Tab DD-13)

(c) Inspection of Mishap Aircraft and Retained Parts

The Accident Investigation Board (AIB) inspected the mishap aircraft at its storage location in Hangar 3102 on Tinker AFB, as well as the flap drivescrew assembly parts that had remained with the aircraft through landing. (Tab Z-33 to Z-52)

(d) Observation of 565 AMXS B-52 PDM Work Area

The AIB observed the PDM dock facility in Building 2121 where the 565 AMXS performed the work on the MA. (Tab Z-27 to Z-30)

(e) Observation of 552 CMMXS Flap Drivescrew Work Area

The AIB observed the Wheel and Gearbox Shop facility in Building 2210 where the mechanics performed the overhaul of the flap drivescrew assemblies from the MA. (Tab Z-3 to Z-10)

(f) Inspection of Flap Impact Sites and Drivescrew Parts

The AIB visited the impact sites of the flaps. On 15 December 2012, the AIB discovered the #5 flap drivescrew near the flap impact points, with the aft end stuck in the ground, as shown in Figure 12. (Tab Z-23 to Z-25) The AIB determined this drivescrew was the #5 drivescrew based on a comparison of a serial number (#136) stamped on the drivescrew nut with the serial number recorded on the Serviceable Tag (DD Form 1574) that was in the aircraft maintenance records. (Tab Z-26) A B-52 SPO engineer inspected the recovered #5 drivescrew. (Tab DD-7)

Figure 12. Recovered Drivescrew

(g) Evaluation of Drivescrew Assembly Failure Modes

The AIB performed a limited analysis of the characteristics of a flap drivescrew assembly with and without the retainer plug installed during a visit to 552 CMMXS. (Tab Z-10)

(h) Evaluation of Broken End Plate Piece Found on Runway

The AIB evaluated photographs of a broken aircraft part taken on 1 November 2012 at approximately 1330L, shortly after the MA took off. (Tab Z-63 to Z-64) The part was found on Runway 18, just east of the runway centerline, near the intersection with Taxiway Delta. (Tab AA-9) By matching the fracture patterns with the end plate pieces that remained attached to the MA, the AIB determined that this part was a broken piece of the end plate from the #4 flap drivescrew. (Tab Z-65 to Z-67)

(2) Damage Descriptions

(a) Inboard Wing Flaps

Both inboard wing flaps completely separated from the aircraft during the mishap flight. (Tab J-7, J-10) The right flap separated first, landing in a wooded area approximately 3.0 miles south of the departure end of Runway 18 at Tinker AFB. (Tab DD-3) Most of the left flap separated in one large piece approximately 20 seconds after the right flap, landing in a wooded area approximately 3.6 miles south of the departure end of the runway. (Tabs V-1.6 and DD-3) The remainder of the left inboard flap, measuring about five feet wide by eight feet long, remained attached to the outboard flap carriage mechanism, which had jammed into the forward end of its track on the bottom of the wing. (Tabs J-7, S-7 to S-11, and S-15 to S-16) This section separated from the aircraft during landing approximately 100 feet behind the point where the aircraft came to a stop on the runway. (Tab S-7 to S-11)

All the components of the inboard flaps were damaged, with some parts remaining attached to the aircraft, some remaining attached to the flaps at their impact point, and others were never recovered. (Tab J-7 to J-13)

(b) Wings

The left and right inboard flap tracks bent outwards slightly, likely due to the flaps departing the aircraft in flight. (Tab J-10, J-12) Additionally, there is a notch in the trailing edge of the right wing, about 12 inches outboard of the right inboard flap. (Tab J-7, Z-49 to Z-52) This was likely caused by the right inboard flap rotating outwards as it departed the aircraft, striking the trailing edge of the wing. (Tab DD-15) There is no evidence this damage contributed to the mishap.

(c) Fuselage

The fuselage skin was damaged by the inboard edge of the flaps on both sides. The damage to the fuselage skin occurred as the inboard flaps rotated aft, rubbing against the fuselage prior to departing the aircraft. (Tabs J-10, J-12)

The miniature radio transceiver (MRT) antenna fairing, on the fuselage aft of the right wing, also showed damage from an apparent impact. (Tab Z-28) It is likely either the flap or parts of the flap impacted the antenna, causing this damage.

(3) Analysis of Facts

(a) Separation of Flaps from Aircraft

The first materiel failure was of the #4 drivescrew end plate. This is supported by the discovery of the broken end plate piece on the runway shortly after takeoff. (Tabs Z-63, Z-64 and AA-9) Since the end plate was found approximately 6,000 feet down the runway, and the calculated takeoff distance was approximately 4,600 feet, we can conclude the end plate fell off shortly after the aircraft became airborne. (Tab AA-11) Although the exact sequence is impossible to determine, this failure was not enough to cause the immediate loss of the rest of the flap structure.

Approximately one minute later, the inboard flaps departed the aircraft during flap retraction when the flaps were at a mid-range position. The flap drivescrews were pulled backwards by the high drag loads against the flaps during takeoff, climbout, and flap retraction. (Tab J-17) The retainer plugs that should have resisted the drag loads were not present in the inboard flap drivescrew assemblies on both the #4 and #5 drivescrews (the inboard actuators of the inboard flaps). These missing parts exposed the end plates at the aft end of the drivescrews to forces beyond their limits, causing them to fail. (Tab J-17, J-18)

With this loss of support, the #4 and #5 drivescrews slid aft until the forward end of the drivescrew fell free of the trunnion, allowing the drivescrew to drop away from the aircraft. The inboard flaps, pushed by aerodynamic drag, pivoted aft around the #3 and #6 drivescrew attachments, allowing the inboard edge of the flaps to rub against the fuselage. This also allowed the inboard flap carriages to slide freely off the aft end of their tracks. The continuing retraction of the #3 and #6 flap actuators contributed to this twisting of the flaps. Exposed to drag loads and bending forces beyond their limits, the outboard carriages and drivescrew attachments failed by bending or breaking. This allowed the flaps to fall free of the aircraft. (Tab J-17, J-18)

(b) Order of Flaps Separation

For undetermined reasons, the right flap failure occurred approximately 20-30 seconds before the left flap failure. (Tab V-1.6) The right flap impacted the ground approximately 0.6 miles closer to the runway than the left flap. (Tabs Z-73 and DD-3) Based on MP1's statement that full flight control inputs were unable to counter the uncommanded roll after the first flap failure, it is likely the pilots could not have recovered the aircraft to a safe landing if the second flap had not fallen off shortly after the first. (Tab V-1.6)

(c) Retainer Plug Absence

The retainer plugs were not present in the #4 and #5 flap drivescrew assemblies. (Tab J-13 to J-14) Post-flight disassembly and visual inspection of the #4 and #5 trunnions, splined adapters and adapter tubes showed no signs of a retainer plug. Inspections of these retained parts also showed no damage consistent with a broken retainer plug. (Tab J-17 to J-18) Further, the lack of damage to the inside threads of the recovered drivescrew confirmed the retainer plugs were not present in the #4 and #5 flap drivescrew assemblies. (Tabs Z-25 and DD-7) Their absence left the drivescrew assembly unable to resist the drag loads experienced during flap retraction. (Tab J-13, J-14, J-17, J-18)

(d) Ground Operational Flap Checks

The forces imposed on the flap drivescrew assembly during ground operational checks would not have been enough to reveal a missing retainer plug. The primary force affecting the drivescrew during these checks is weight, which is supported by the flap carriages and tracks. The strength of the end plate was enough to hold the assembly together during ground operations, but was not sufficient to resist the additional drag loads in flight. (Tab J-18)

(e) Drivescrew Overhaul Process

The AIB's post-mishap investigation of the B-52 PDM process became focused on the flap drivescrew assembly overhaul process based upon the physical evidence. The retainer plugs should have been installed during the component-level overhaul performed by the 552 CMMXS Wheel and Gearbox Shop. (Tabs D-75 to D-90, and Z-3) Of the 8 drivescrews on the B-52, the specific retainer plug design varies based on position. (Tab DD-13) On the left side of the aircraft, the #1, #2, #3 and #4 drivescrews each use a different type of retainer plug.

This pattern is mirrored on the right side of the aircraft, with the #4 and #5 drivescrews using the same type of plug, and so on. (Tab DD-13 to DD-14) The two failed drivescrew assemblies shared identical retainer plugs, not found on the other six drivescrew assemblies. (Tab DD-14) This helped explain how the mistake was limited to these two drivescrew assemblies.

The procedures for overhauling the flap drivescrew assemblies are in Technical Order (T.O.) 16G3-2-21-3. (Tab BB-25 to BB-35) The WCDs the mechanics use reference this T.O. and guide how to overhaul the drivescrew from disassembly to reassembly. The mechanic signs off the work as completed by stamping the WCD. (Tab D-75 to D-90) The final step requires the mechanic to safety-wire the gearbox and adapter tube to the trunnion in order to hold the assembly together during transport to the aircraft. (Tab V-5.18) However, the WCD does not require an additional mechanic to inspect or certify the primary mechanic's work before the assembly is safety-wired closed and prepared for transport back to 565 AMXS. (Tab D-75 to D-90) The lack of a second mechanic's inspection sacrificed the opportunity for another person to notice the retainer plugs were missing from the #4 and #5 drivescrews.

AFI 21-102, para 13.12.5, specifies that work identified as "critical" requires a secondary certification. Per that AFI, work is critical if end item failure affects safety of flight. (Tab BB-22) A 565 AMXS planner created the WCD that did not require secondary certification. (Tabs BB-20 and DD-14) The planner used a template that was last reviewed in 2008. (Tab D-75 to D-90) The AIB could not determine who made the decision that this particular task was not critical.

(f) Drivescrew Maintenance Documents

Within the 552 CMMXS Wheel and Gearbox Shop, several maintainers (MX1 to MX4) were involved with flap drivescrew assembly overhauls. The WCDs showed a single maintainer (MX1) performed all of the disassembling, cleaning, inspecting and reassembling on all eight drivescrew assemblies on the MA. (Tab D-75 to D-90) MX4 received some training on the drivescrew overhaul process from MX1 starting in late July 2012, but did not complete the training and become certified. (Tabs U-3 and V-5.15, V-7.21, and V-8.1) While it is possible MX4 performed some of the work on the MA drivescrew assemblies under the supervision of MX1, there is not sufficient evidence to verify this as a fact.

The task of overhauling a set of eight flap drivescrew assemblies required at least one week to complete, but MX1 was signing or "stamping" off work at the end of the whole task, as opposed to at the completion of each step. (Tab V-5.4) Even though each individual drivescrew had its own WCD, MX1 worked the assemblies in parallel and signed all the WCDs together at the end. (Tab V-5.4) In the case of the drivescrews for the MA, MX1 stamped all the work on 6 August 2012, although he completed the work during the 1-2 weeks prior. (Tab D-75 to D-90) Further, since 6 August 2012 was a Monday, there were at least two non-duty days between the majority of the work and MX1 signing the WCDs. This practice prevented the WCD from acting as a checklist, as designed, to prevent the mechanic from missing any steps. (Tab V-13.1)

There was no additional oversight or certification of this task recorded on the documents. (Tab D-75 to D-90) However, there was no requirement for oversight or certification of this task, per OC-ALC application of AFI 21-102 guidance. (Tabs D-75 to D-90, and BB-22)

(g) Drivescrew Transportation

The drivescrews were transported from the 552 CMMXS Wheel and Gearbox Shop work area in Building 2210 to the 565 AMXS work area in Building 2121 in a horizontal position on a wooden pallet. (Tabs S-61, V-5.5 and V-7.6) From the pallet, AMXS personnel carried them up a short set of stairs to a work platform for partial disassembly, before installation in the wing. (Tab V-10.1)

During the transportation process, it is possible the drivescrew assembly would have fallen apart if the retainer plug was not installed. If the drivescrew had been held at a steep angle with the gearbox end closest to the ground, the trunnion would have slipped off the drivescrew since the retainer plug would not have been there to hold it on. (Tab Z-10) This would have alerted the maintainers to an error and thus prevented the mishap.

Cursory testing of this condition in the 552 CMMXS Wheel and Gearbox Shop area indicated could be held at an incline of approximately 20-30 degrees before this would happen. (Figure 13) The photo below shows a drivescrew assembly, with the retainer plug not installed, being held at such an angle, without the trunnion and splined adapter sliding off. (Tab Z-10) The exact angle required would likely depend on several factors such as part tolerances, grease consistency, and vibration. However, if the drivescrew assembly was kept horizontal, or if the gearbox end of the assembly was held higher than the drivescrew end, the assembly would likely remain together and the missing retainer plug would not be detected.

Figure 13. Drivescrew Held at Incline with Retainer Plug Missing

Based on mechanic testimonies and due to the weight distribution that makes the gearbox end of the drivescrew assembly the heaviest, the drivescrews are normally carried in a horizontal to slightly inclined position, with the gearbox end held higher. (Tab DD-13) Therefore, it is reasonable to conclude that two flap drivescrew assemblies with retainer plugs not installed could have made it through the transportation and installation process undetected.

(h) Drivescrew Installation

Within the 565 AMXS, several maintainers (MX5 to MX7) were involved with flap drivescrew assembly installation. The #4 drivescrew was installed on the MA by MX7, and the #5 drivescrew was installed by MX6. (Tab U-17 to U-18) The drivescrew assembly installation for the #4 and #5 drivescrews required the mechanic to separate the gearbox from the drivescrew by cutting the safety wire which attached the gearbox to the drivescrew. (Tab V-10.1) This allowed the mechanic to install the gearbox in the forward end of the drivescrew housing. (Tab V-10.1) This also exposed the top end of the drivescrew where the retainer plug should have been visible, and presented an easy opportunity for the mechanic to visually notice a missing retainer plug. (Tab V-10.1) However, neither the T.O.s nor the WCDs for drivescrew installation instructed the mechanics to visually check for this part. (Tabs U-17 to U-18, and DD-13) In addition, the mechanics who performed this task were not familiar enough with the inside of the drivescrew assembly to recognize the retainer plug's absence. (Tabs V-9.1, V-10.1 and DD-13) Instructing the installing mechanics to make a simple visual inspection could have revealed the missing part and prevented the mishap.

7. WEATHER

a. Forecast Weather

Weather conditions at takeoff time were forecast to be less than 28 degrees Celsius; with winds from 250 degrees magnetic at 9 knots; the minimum altimeter setting was 29.92; with clear skies; and unrestricted visibility. (Tab W-3)

b. Observed Weather

Weather conditions at takeoff time were reported to be: 21 degrees Celsius; with winds from 330 degrees magnetic at 3 knots; the altimeter setting was 29.99; with clear sky; and visibility was 10 miles. (Tab F-8)

c. Space Environment

Not applicable.

d. Operations

The mission was flown IAW AFI 11-202 Vol. 3, *General Flight Rules*, weather requirements. These observed weather conditions are typical for the region and time of year; they presented no remarkable challenges to the mishap crew. (Tab V-1.5)

8. CREW QUALIFICATIONS

a. Mishap Pilot 1 (MP1)

At the time of the mishap, MP1 was a qualified Instructor Pilot, Evaluator Pilot, and Functional Check Flight Pilot in the B-52H with 4,351 hours of total time and 2,460 hours as a pilot in the B-52H. (Tab G-5) All necessary flight currencies were up-to-date and all required training for the planned mission was current IAW AFI 11-2B-52, v1, *B-52 Aircrew Training*. (Tab G-7 to G-9) MP1 performed his last instrument/ qualification/ instructor evaluation on 25 September 2012. He was rated qualified. (Tab G-3 to G-4)

Recent flight time/ sorties are as follows (Tab T-5):

	Hours	Sorties
Last 30 Days	12.2	10
Last 60 Days	29.2	19
Last 90 Days	34.3	22

b. Mishap Pilot 2 (MP2)

At the time of the mishap, MP2 was a qualified Instructor Pilot in the B-52H with 2,519 hours of total pilot time and 1,630 hours as a pilot in the B-52H. (Tab G-13) All necessary flight currencies were up-to-date and all required training for the planned mission was current IAW AFI 11-2B-52, v1, *B-52 Aircrew Training*. (Tab G-14 to G-15) MP2 performed his last instrument/ qualification/ instructor evaluation on 16 October 2012. He was rated qualified. (Tab G-16)

Recent flight time/ sorties are as follows (Tab T-9 to T-13):

	Hours	Sorties
Last 30 Days	18.7	4
Last 60 Days	48.8	11
Last 90 Days	72.3	16

c. Mishap Radar Navigator (MRN)

At the time of the mishap, MRN was a qualified Instructor Radar Navigator in the B-52H with 2,192 hours. (Tab G-19) All necessary flight currencies were up-to-date and all required training for the planned mission was current IAW AFI 11-2B-52, v1, *B-52 Aircrew Training*. (Tab G-21 to G-22) MRN performed his last mission/ qualification/ instructor evaluation on 25 August 2011. He was rated qualified. (Tab G-17 to G-18)

Recent flight time/ sorties are as follows (Tab T-3):

	Hours	Sorties
Last 30 Days	12.2	10
Last 60 Days	29.2	19
Last 90 Days	34.3	22

There is no evidence to suggest crew qualifications were a factor in this mishap.

d. Maintainer 1 (MX1)

MX1 was a qualified mechanic certified to sign off work completion of B-52 flap drivescrew assemblies since 2008. (Tab G-47) MX1 worked in the 552 CMMXS Wheel and Gearbox Shop since 2004. MX1's last personnel evaluation (PE) by Quality Assurance was completed on 26 January 2012 on the disassembly of an E-3 Flap Drive Angle Gearbox. (Tab U-5) MX1 received a PE on B-52 flap drivescrew assemblies, on 12 February 2008. This PE covered installation of the link assemblies only and MX1 received a pass rating. This PE did not cover the assembly of the forward section of flap drivescrew assemblies, to include the retainer plug installation. (Tab U-6) MX1 never received a PE on the assembly of the forward section of flap drivescrew assemblies, to include the retainer plug installation. (Tab DD-11) There is no requirement to receive a PE on each task a maintainer is certified on. (Tab DD-14)

9. MEDICAL

a. Qualifications

The MC was medically qualified to perform flying duties at the time of the mishap. Each member of the MC was up-to-date on annual Preventive Health Assessments and was qualified at the time of the mishap. (Tab DD-19)

The medical records of the maintainers involved in the mishap were unavailable for review.

b. Health

The MC's medical records were reviewed. Each crewmember was cleared medically for flying duties. (Tab DD-19)

c. Pathology

Not applicable.

d. Lifestyle

There is no evidence to suggest lifestyle factors contributed to the mishap. (Tab DD-19)

e. Crew Rest and Crew Duty Time

All aircrew are required to have proper crew rest prior to performing flying duties as outlined in AFI 11-202, v3. The AFI defines proper crew rest as a minimum of a 12-hour non-duty period before the designated flight duty period begins. During this time, an aircrew member may participate in meals, transportation or rest as long as he or she has had at least 10 hours of continuous restful activity with an opportunity for at least 8 hours of uninterrupted sleep.

There is no evidence to suggest inadequate crew rest contributed to the mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The 10 FLTS did not have an elevated operations tempo in the months prior to the mishap. The mishap pilots and MRN flew 10 or less sorties in the preceding month. (Tab T-3, T-5, T-9 to T-13)

The 552 CMMXS Wheel and Gearbox Shop did not have an elevated operations tempo in the months preceding the mishap. Most civilian employees worked a standard 40 hour work week. Although shift times varied, most employees worked Monday to Friday, early morning until mid-afternoon. (Tab DD-9)

There is no evidence that operations tempo was a factor in this mishap.

b. Supervision

10 FLTS reviewed and approved the mishap sortie, as well as ensuring members received the proper training. (Tab DD-17) There is no evidence that 10 FLTS supervision was a factor in this mishap.

The 552 CMMXS Wheel and Gearbox Shop had an inadequate training program for the drivescrew overhaul process, contrary to the requirements of AFI 21-102. (Tabs U-3, BB-22 to BB-23, and DD-9) This allowed the primary mechanic to train his/ her replacement without reference to an approved training plan, which would have specified detailed training criteria for a flap drivescrew overhaul. (Tabs V-5.11, V-5.14, V-5.20, V-7.6, V-7.10 and BB-22) This created a situation where T.O. deviations were passed from one mechanic to the next. (Tab V-5.11, V-5.14, V-5.20, V-7.6, V-8.1)

11. HUMAN FACTORS

a. Introduction

AFI 91-204, *Safety Investigations and Reports,* 24 September 2008, Attachment 5, contains the Department of Defense Human Factors Analysis and Classification System, which lists potential human factors that can play a role in any mishap. (Tab BB-47) Human factors consider how people's tools, tasks and working environment systematically influence human performance. (Tab BB-47 to BB-50)

b. Applicable Factors

There is no evidence that any human factors significantly contributed to this mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
(2) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008
(3) AFI 11-202, v3, *General Flight Rules*, 22 October 2010
(4) AFI 11-2B-52, v1, *B-52 Aircrew Training*, 8 September 2011
(5) AFI 11-2B-52, v3, *B-52 – Operations Procedures*, 24 September 2012
(6) AFI 21-102, *Depot Maintenance Management*, 18 July 2012

NOTICE: All directives and publications listed above are available digitally on the AF Departmental Publishing Office internet site at: http://www.e-publishing.af.mil.

b. Other Directives and Publications Relevant to the Mishap

(1) T.O. 16G3-2-21-3
(2) T.O. 16G3-2-21-4

c. Known or Suspected Deviations from Directives or Publications

552 CMMXS Wheel and Gearbox Shop consistently deviated from the reassembly procedures detailed in T.O. 16G-2-21-3, specifically step “r” on page 2-10. Step “r” required the mechanic to torque the plug to “between 450 to 500 pound inches with wrench, Part No. F52141-500.” (Tab BB-31) The process required a specialized adapter for the torque wrench; however, the adapter had been missing for years. (Tabs V.7.6 to V-7.7, V-7.14, and Z-77 to Z-78) Instead, the mechanics involved in the reassembly over at least the past six years installed the plug to “finger tight,” before using a chisel and hammer to torque it “slightly tighter.” (Tab V-5.11, V-7.6) Although the mechanics incorrectly installed the retainer plug, its anti-rotation provisions would have prevented the retainer plug from falling out, so there is no evidence that this deviation contributed to this mishap.

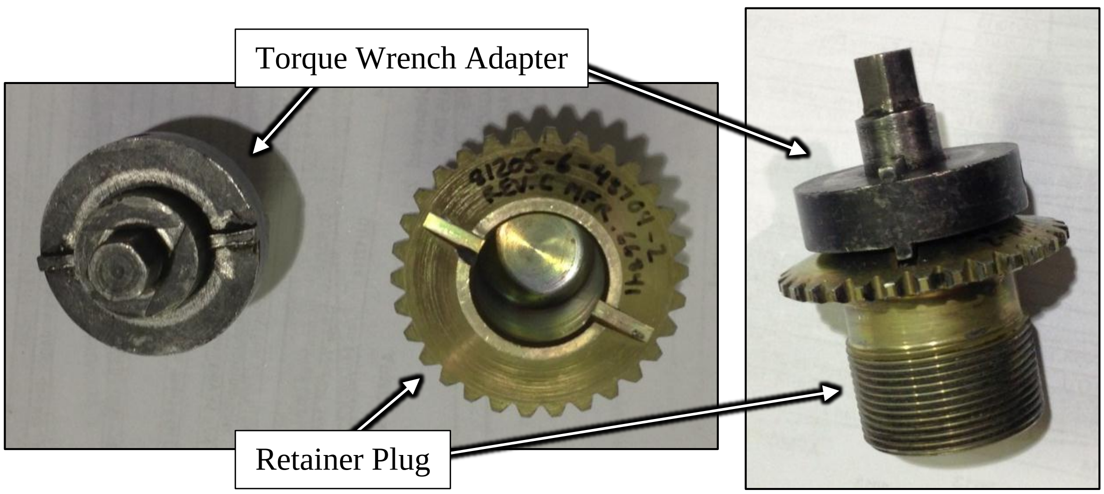

Figure 14. Retainer Plug and Torque Wrench Adapter

552 CMMXS Wheel and Gearbox Shop also deviated from T.O. 16G-2-21-3 in regards to the alteration of retainer plugs which did not meet specifications. (Tab DD-14) The retainer plugs for the #3 and #6 drivescrews arrived at the Wheel and Gearbox Shop work area without two holes and a groove in the cap, which the design required. The T.O. authorized altering these retainer plugs by drilling holes into them. (Tabs BB-29 and DD-14) However, the Wheel and Gearbox Shop was also grinding notches in the retainer plugs without specific guidance and authorization. (Tab V-5.20) In order to keep things moving, mechanics adopted the practice of grinding the groove into the new parts, using the old parts removed from the drivescrew assemblies as a template. (Tab DD-14) These alterations did not affect the #4 or #5 drivescrew assembly retainer plugs, so there is no evidence that this deviation contributed to this mishap.

13. ADDITIONAL AREAS OF CONCERN

Although not causal, the two known deviations from T.O. 16G-2-21-3 and the lack of an adequate training plan are areas of concern, as discussed in sections 10 and 12 above.

OC-ALC Quality Assurance (QA) had not completed a task or personnel evaluation on the entire B-52 flap drivescrew assembly overhaul process during the past four years. (Tabs U-5 to U-14, and DD-11) QA had conducted eight quality verification inspections and one PE, but none of these appeared to cover the entire overhaul process, and they all failed to identify the T.O. deviations. (Tab U-5 to U-14) This failure allowed the mechanics to continue to deviate from the T.O. and even gave the appearance of QA endorsement of their practices.

Prior to routing the B-52 flap drivescrew assemblies to 552 CMMXS Wheel and Gearbox shop for overhaul, 565 AMXS created the flap drivescrew assembly WCDs using a computer generated template. (Tab DD-13) The 552 CMMXS Wheel and Gearbox Shop used these WCDs, in conjunction with the T.O.s, to overhaul the flap drivescrew assemblies. (Tab V-7.9) The B-52 flap drivescrew is the only assembly the 552 CMMXS Wheel and Gearbox Shop overhauls that is routed directly from a depot squadron. All of the other assemblies are routed to the 552 CMMXS through Defense Logistics Agency (DLA), which then provides the overhauled parts to the depot squadrons through the normal supply process. Currently, the B-52 flap drivescrew assembly does not have a national stock number (NSN) assigned to it, preventing 565 AMXS from ordering the part from DLA. (Tab DD-14)

The other assemblies routed through DLA arrive at the 552 CMMXS with much more detailed and thorough WCDs. (Tab V-13.1) To illustrate, the B-52 flap drivescrew assembly WCD contained only four steps: (1) replace all components, (2) reassemble gearbox, lubricate and install screw assembly, (3) test, and (4) assemble carriage assembly/ record gearbox serial number. (Tab U-71 to U-72) In contrast, comparable components from DLA listed much more detailed instructions describing the work steps to be accomplished in a checklist format. (Tab V-7.5, V-13.1) The overly vague WCD steps for the B-52 flap drivescrew assembly placed too much reliance on the individual mechanic's knowledge and expertise to avoid mistakes. The vague WCD steps, coupled with a desire to keep the line moving in the face of supply or tool shortfalls, also may have encouraged T.O. deviations like the ones previously noted.

4 January 2013

DAVID F. WRIGHT, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

B-52H, T/N 61-0014
Tinker Air Force Base, Oklahoma
1 November 2012

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On 1 November 2012, at approximately 1237 hours local time (L), a B-52H, tail number (T/N) 61-0014, assigned to the Oklahoma City Air Logistics Complex, Tinker Air Force Base (AFB), Oklahoma (OK), lost the inboard flap sections from each wing shortly after takeoff. (Tab V-1.3 to V-1.9) No one involved in the mishap sustained any injuries. (Tab V-1.10) The mishap aircraft (MA) suffered extensive damage to both wings and the fuselage. (Tab J-7 to J-13) There was no damage to private property, although the flaps fell in a heavily wooded area owned by Oklahoma City. (Tab DD-3) The estimated repair cost of the MA is $1.08 million. (Tab P-4)

I find by clear and convincing evidence that the cause of the mishap was a failure by maintenance, and specifically by one maintainer (MX1) in the 552d Commodities Maintenance Squadron (CMMXS) Wheel and Gearbox Shop, to install the retainer plugs in the forward end of the flap drivescrew assemblies in the inboard flap actuators (#4 and #5) of both inboard flap sections on the mishap aircraft.

Additionally, I find by a preponderance of the evidence that the following three factors substantially contributed to the mishap:

(1) the lack of an oversight requirement in the 552 CMMXS Wheel and Gearbox Shop for an independent certification by another mechanic of the work done overhauling the flap drivescrew assemblies;

(2) the lack of a procedural requirement in the 565th Aircraft Maintenance Squadron Programmed Depot Maintenance dock for personnel installing the flap drivescrews to perform a cursory inspection of the flap drivescrew assemblies to verify that they are properly assembled; and

(3) the maintenance documentation practices in the 552 CMMXS Wheel and Gearbox Shop which allowed work to be signed off several days after it had been accomplished.

I developed my opinion by analyzing factual data from expert analysis of the physical evidence at the impact sites, from evaluations of the mishap aircraft and its parts, from a review of the

B-52 maintenance processes in the Oklahoma City Air Logistics Complex (OC-ALC), and from interviews with the aircrew and maintainers involved.

2. CAUSE

The root cause of the mishap was the failure to install the retainer plugs in the #4 and #5 flap drivescrew assemblies on the mishap aircraft. There is no physical evidence, and no convincing documentary evidence, that indicates that the retaining plug was installed during the overhaul of the flap drivescrew assembly during depot maintenance at OC-ALC facilities at Tinker AFB, OK.

This conclusion is supported by the following evidence:

(1) the retainer plugs were not found within their assemblies after landing (Tab J-14);

(2) the remaining parts of the forward end of the #4 and #5 flap drivescrew assemblies showed no damage that would indicate failure or forcible removal of the retainer plug (Tab J-14);

(3) the pattern of failure of the #4 and #5 flap drivescrew end plates which show they failed due to excessive force pushing them aft, which is consistent with the retainer plugs not being present to bear the load caused by aerodynamic drag in flight (Tab J-14); and

(4) the lack of evidence, testimony, or motive that would indicate that the retainer plugs were removed at some point after leaving the 552 CMMXS Wheel and Gearbox Shop.

MX1 was responsible for the reassembly of the #4 and #5 flap drivescrews as indicated by MX1 being the only individual who signed off on the work control documents (WCD). (Tab D-81 to D-84) Interviews of personnel in the shop indicated that no one else would have performed this work in place of MX1. (Tab V-6.1, V-13.1, V-14.1) MX1 was doing some training of another maintainer (MX4) on this task during the same timeframe. (Tab V-5.15, V-8.1) I could not determine precisely why MX1 did not install the retainer plugs, but it is possible that training MX4 on the task altered the normal routine and allowed MX1 to make this mistake.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

a. Lack of Oversight Requirement in 552 CMMXS

At the time the work was completed on the flap drivescrew assemblies of the MA, the 552 CMMXS Wheel and Gearbox Shop did not require a second mechanic to inspect or certify the work done by MX1. (Tabs D-71 to D-90, V-6.1, and Tab DD-14) The determination which deemed this task as non-critical failed to recognize the safety-of-flight impact this part could have, which should have required a secondary certification per AFI 21-102. (Tab BB-22) A simple inspection of the work prior to the final assembly would have revealed the mistake and prevented the mishap.

b. Lack of Procedural Requirement in 565 AMXS

At the time the flap drivescrew assemblies were installed on the MA, the technical order (T.O.) did not require the 565 AMXS mechanic performing the installation to do a cursory inspection of the assembly. (Tabs U-17 to U-18, V-9.1, V-10.1, and DD-13) Since the installation procedure involved separating the drivescrew assembly at the point where the adapter tube slides over the splined adapter and retainer plug, even a quick glance would have revealed the retainer plug's absence and thus prevented the mishap.

c. Maintenance Documentation Practices

MX1 routinely stamped the flap drivescrew assembly WCDs at the end of the complete task, as opposed to at the completion of each step. The task of overhauling a set of eight flap drivescrew assemblies took over a week, but MX1 was signing off work at the end of the task that had been performed several days earlier, often with non-duty weekend days in between. Even though each drivescrew had its own WCD, the paper work was signed off all at once when all work was completed. (Tab V-13.1) In the case of the drivescrews for the MA, all the work was stamped by MX1 on 6 August 2012, a Monday, although the work was actually done during the 1-2 weeks prior. (Tabs D-71 to D-90, and V-13.1) This practice reduced the effectiveness of the stamping process for preventing any missed steps in the overhaul process. If MX1 had stamped the WCDs as each step was completed, it is probable MX1 would have noticed the missing retainer plugs and thus prevented the mishap.

4. CONCLUSION

By clear and convincing evidence, I find that the cause of the mishap was a failure of maintenance, and specifically one maintainer, to install a critical part in two flap actuators. Further, I find by a preponderance of evidence that the processes and T.O.s in place covering B-52 depot overhauls made it possible for one person's mistake to make it through the system unnoticed, to get installed on an aircraft, and not to become apparent until the systems were exposed to the unique forces imposed by flight, when they failed catastrophically.

It was only by chance that the two flaps fell off at nearly the same time, and that the flaps fell in an uninhabited area where no one was hurt. It is a testament to the skill of the aircrew, with outstanding support from their squadron operations personnel and air traffic control, that they recovered the aircraft safely.

4 January 2013

DAVID F. WRIGHT, Lt Col, USAF
President, Accident Investigation Board

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